NOTES ON TRANSFUSION

ISSUED BY THE
MINISTRY OF HEALTH IN ASSOCIATION WITH
THE DEPARTMENT OF HEALTH FOR SCOTLAND
FOR THE
NATIONAL BLOOD TRANSFUSION SERVICE AND
THE SCOTTISH BLOOD TRANSFUSION SERVICE

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P. N. Burton Jones.

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This edition of " Notes on Transfusion ", like the two previous editions, has been prepared by the Committee of Regional Transfusion Directors of the Ministry of Health. The booklet is intended primarily for use by medical staff of hospitals and its purpose is to describe briefly some of the principles of the practice of transfusion and to suggest procedures; it is not intended that the booklet should supersede already established local practice and procedures without the agreement of those concerned. These notes are not exhaustive or exclusive, for the subject is too large for all methods and procedures in use to be described.

NOTES ON TRANSFUSION

Transfusion therapy should be undertaken only after careful assessment of the patient's clinical condition to determine the nature and quantity of fluid to be transfused and the rate of administration. The patient may require whole blood, concentrated red cells, or plasma. A transfusion should never be given without a definite indication; not only is this in the patient's interest but supplies of blood are not unlimited and with the ever-growing demand for blood it is imperative that it is not used unnecessarily.

I. Choice of Fluid

1. WHOLE BLOOD is used to restore blood volume or the oxygen-carrying capacity of the blood, or to replace one or more missing elements of the blood. A standard bottle contains approximately 540 ml. citrated blood (approximately 420 ml. blood and 120 ml. acid-citrate-dextrose anticoagulant solution).

Blood is sometimes indicated for:—

(i) Haemorrhage—acute or chronic.
(ii) Certain forms of anaemia—acute or chronic.
(iii) Oligaemic shock.
(iv) Certain blood dyscrasias, e.g., haemophilia, haemorrhagic disease and haemolytic disease of the new born, aplastic anaemia, etc.

2. CONCENTRATED RED CELLS are ideal for the treatment of anaemic states in which it is desired to raise the haemoglobin level, and in which blood volume restoration is not required. A bottle contains the cells from one or more bottles of whole blood. Concentrated red cells should be used as soon as possible, and not more than 12 hours, after preparation.

3. POOLED PLASMA OR SERUM (dried or fluid) should be reserved for the following conditions:—

(i) Burns and crush injury.
(ii) Oligaemic shock due to haemorrhage: plasma or serum may be used in cases of blood loss in childbirth or during operation, gastro-intestinal haemorrhage, etc., until compatible blood is available.

A bottle of dried plasma or serum contains the dried solids from 400 ml. citrated plasma (serum). A bottle of fluid plasma contains approximately 500 ml. citrated plasma.

Pooled plasma or serum may be given without regard to the blood group of the recipient.

(See *also* Section VII (7).)

4. Fresh Blood or Plasma is indicated in conditions where it is essential to restore a factor or factors which deteriorate during storage. Blood should be given if, in addition to the missing factor or factors, red cell replacement is necessary. The two main conditions where fresh blood and/or plasma are required are haemophilia and deficiency of factor V (labile factor).

In haemophilia the transfusion of plasma should be given at a fast rate to raise the level of the anti-haemophilic globulin rapidly. When the patient's condition is such that rapid transfusion may overload the heart, a vigilant watch must be kept on the state of filling of the cervical veins.

5. Plasma Substitutes are solutions of macromolecular substances which possess properties (e.g., viscosity and colloid osmotic pressure) closely resembling those of plasma and are not toxic or antigenic. They do not contain haemoglobin, protein (except in gelatin solutions), antibodies or clotting factors and have only slight buffering effects. They may be given to recipients of any blood group. *Plasma substitutes may interfere with compatibility tests: a specimen of blood for this test should, therefore, always be collected before giving a plasma substitute. If a compatibility test is needed and a plasma substitute has already been given, the laboratory should be informed of this.* Febrile and other forms of reaction may rarely attend the use of plasma substitutes.

Plasma substitutes are not substitutes for whole blood nor are they complete substitutes for plasma. They should, therefore, be used with discretion. Their main use is the restoration of a depleted blood volume when supplies of blood or plasma are lacking or inadequate.

Ideally plasma substitutes (or plasma or serum) should not be given in such quantities that the haemoglobin concentration is depressed below 9·0 g. per cent. (62 per cent. Haldane); in any case the haemoglobin concentration should not be allowed to fall below 7·0 g. per cent. (47 per cent. Haldane) for more than a short time.

Plasma substitutes, particularly dextran, have been used successfully for the resuscitation of casualties with burns. It has been advised that, when large transfusions are needed in the treatment of such patients, the volume of plasma substitute

transfused should not exceed the patient's calculated normal plasma volume. If the patient's transfusion requirements exceed this amount, the transfusion should be continued with plasma if available. If plasma cannot be obtained the treatment should be continued with plasma substitute.

II. Storage of Blood and Plasma and Criteria of Fitness for Use

1. BLOOD

(i) Blood should not be used unless there is a clear line of demarcation between the sedimented cells and the supernatant plasma which should be straw coloured and free from visible signs of haemolysis. Haemolysis may be shown by a reddish purple discoloration in the plasma immediately above the cell layer, which gradually spreads upwards. Fat may collect as a white layer on the surface of the plasma in some bottles but this is not a contra-indication to the use of the blood.

(ii) Time-expired blood must not be used.

(iii) *Storage:* Refrigerators selected for use as blood banks must be kept under constant supervision by a responsible member of the medical staff.

Normally the hospital pathologist is in charge of the blood bank. **The blood bank refrigerator should not be used for the storage of food or pathological specimens.**

The correct temperature for the storage of blood is 4°C.–6°C. (38°F.–42°F.). These limits must be rigidly observed to preserve the red cells and minimize the multiplication of chance bacterial contaminants.

Blood must never be allowed to freeze. Transfusion of blood which has been frozen and thawed may cause death.

Ideally, the refrigerator should have an automatic temperature recording device and a battery-operated alarm system; otherwise a maximum and minimum thermometer should be provided and the temperature recorded morning and evening in a book.

The time during which blood is out of the refrigerator or other cold storage (such as an insulated box) should be reduced to a minimum; and should not exceed 30 minutes on any one occasion, after which the blood should immediately be cooled again to 4°C.–6°C. Blood which has been out of cold storage for longer

periods should not be reserved for future use. Similarly, bottles which have been opened or punctured for sampling and not used within 24 hours, although subsequently kept at 4°C. since sampling, should not be reserved for future use, except at the discretion of the pathologist in charge. Bottles of blood which have been partly used should always be discarded.

Sometimes there is delay between the time at which blood is issued from the blood bank and the time when it is to be used; sometimes requests are made for blood to be issued, e.g., to the operating theatre, in case it may be needed. On such occasions the blood should be kept in a refrigerator at 4°C.–6°C. until it is used, or if there is no refrigerator, it should be issued in an insulated box.

It is advisable to reserve a clearly defined part of the refrigerator for bottles of time-expired blood and blood which has become unfit for use for any other reason. These should not be discarded or allowed to accumulate but should be returned to the regional transfusion centre at the earliest opportunity.

An accurate record of issues must be kept (see Section VI).

2. Concentrated Red Cells should be used as soon as possible and certainly not more than 12 hours after preparation. The blood from which concentrated red cells are prepared should be as fresh as possible, and not older than 14 days.

3. Dried Plasma or Serum

(i) *Reconstitution of dried plasma or serum.* Each bottle issued is accompanied by a bottle containing 400 ml. non-pyrogenic sterile distilled water. Unscrew the caps of the bottle containing the water and the bottle of dried plasma/serum. If possible flame the tops of the bottles and pour the water into the bottle of dried plasma/serum and replace the cap at once. Solution is helped by gentle shaking and should be complete in 4–5 minutes. An opaque solution results due to lipoids in fine suspension. Dried plasma/serum is bottled in dry nitrogen and hermetically sealed. If the seal is damaged moisture may gain access to the plasma/serum and cause denaturation of the proteins, which reduces their solubility. If therefore, after adding water, complete solution is delayed beyond 5–10 minutes, or if a gel forms, the bottle should not be used.

Reconstituted plasma/serum must be used without delay. If not used within 3 hours it should be discarded.

(ii) *Storage:* Dried plasma/serum should be stored at a temperature below 20°C. (68°F.) in a dry, dark place. Refrigeration is not necessary.

4. Fluid Plasma

(i) Fluid plasma should not be used unless it is crystal clear. Cloudiness or deposits may be caused by bacterial contaminants

and plasma showing these changes should be returned to the Regional Transfusion Centre.

(ii) *Storage:* Fluid plasma should be stored at a temperature below 20°C. in a dry, dark place. Refrigeration is not necessary.

5. PLASMA SUBSTITUTES

(i) Solutions of plasma substitute should not be used unless they are crystal clear and free from deposits.

(ii) *Storage:* Solutions of plasma substitute should be stored at a temperature below 20°C. in a dry, dark place. Refrigeration is not necessary.

III. Volume and Rate of Transfusion

Dogmatic directions cannot be given concerning the volume and rate of transfusion. The following factors must be considered—the age of the patient, the general condition, the state of the circulatory system, and the indication for the transfusion. The young adult, with a normal myocardium, will tolerate the rapid infusion of relatively large quantities of protein fluid, even when the blood volume is normal. On the other hand, the chronically anaemic patient with an enfeebled myocardium, or those with respiratory or cardiac disorders, or infective and toxic conditions must be transfused very cautiously.

(1) In the presence of a severe injury accompanied by internal or external loss of blood, the rapid and adequate restoration of the blood volume is the immediate aim, and sufficient blood (or where sufficient blood is not available, plasma and blood in ratio 1 : 2) to raise the systolic blood pressure to at least 100 mm.Hg. should be given. *In the previously healthy* patient, a rate of 100 ml./minute will usually be tolerated until the B.P. reaches 100 mm.Hg. Thereafter the rate should be slowed and the transfusion continued slowly to maintain the systolic blood pressure at its normal level. The transfusion should not be taken down, since further fluid may be needed during and after operation. For general purposes the patient's systolic blood pressure is a rough guide to the amount of fluid to transfuse. *Therefore, the blood pressure should be recorded regularly throughout the transfusion and at least after each bottle transfused.*

(2) In treating anaemia it may be assumed that one standard bottle of whole blood will raise the haemoglobin some 1·0 g. per cent. (7 per cent. Haldane), and one standard bottle of concentrated red cells (the cells from 2 bottles of whole blood) will raise the

haemoglobin some 2·0g. per cent. (15 per cent. Haldane). If the volume of whole blood required to raise the haemoglobin to the chosen level exceeds one third of the calculated blood volume (40 ml./lb./ body weight), the transfusion should be given in two parts, separated by 2 days.

The rate of administration should not exceed 20–40 drops per minute, and in *chronic anaemias* with haemoglobin value of less than 3·7g. per cent. (25 per cent. Haldane), *cachexia, cardiac or respiratory disease*, this rate should be halved. The chosen rate of flow should be constantly and accurately maintained, and watch kept for cardiac embarrassment. (The venous pressure is a most valuable sign, and the state of filling of the jugular veins should be closely observed. The base of the lungs should be examined at frequent intervals for signs of pulmonary oedema.) Similar caution must be used in transfusing *septic* and *toxic patients*. A large volume of fluid, even if administered slowly over a long period, should not be given as a single continuous transfusion to patients with such conditions: it should be divided and given slowly as a number of small transfusions.

Preferably, no major surgical procedure should be carried out unless the haemoglobin is at least 10·4*g. per cent.* (70 *per cent. Haldane*).

If the haemoglobin level cannot be restored by appropriate medical treatment, pre-operative transfusions may have to be given. Such transfusions should be given an adequate time before operation to allow their full benefit to develop and to avoid the possibility of a reaction occurring at a time when it would be masked by anaesthesia.

(For a full consideration of the treatment of wound shock see "The Treatment of Wound Shock", M.R.C. Memorandum No. 34, London, H.M.S.O. 1957).

IV. Blood Grouping and Compatibility Testing

In the interests of safety, blood grouping and compatibility testing should only be performed by persons, whether doctors or technicians, who have had special instruction in modern techniques of such tests. Instruction in the techniques of blood grouping and compatibility testing can, if desired, be obtained at Regional Transfusion Centres. For these reasons no attempt is made to describe these techniques here.

Whatever form local arrangements may take, and whichever of the various recognised techniques of blood grouping and compatibility testing may be adopted, it is essential that a definite order of procedure be evolved and rigidly followed. The order of procedure, including details of techniques to be used, should be written out and be familiar not only to the laboratory staff but also to any other members of the hospital staff who may have to perform blood grouping tests. The necessary pipettes, tubes, saline solutions etc., should always be kept in the same place. Antisera for use should (i) be labelled, (ii) be of adequate potency, (iii) have been subjected regularly and frequently to control tests and (iv) always be kept in the same place in the refrigerator.

There is no laboratory procedure in which the results of erroneous technique or interpretation are more disastrous than in the grouping and compatibility testing of blood. The result of a mistake may be fatal. **The printed directions for carrying out these procedures are deceptively simple and give a false sense of security.** Special training and experience are essential if errors in grouping and compatibility testing are to be avoided.

No patient, except in grave emergency, should be given a blood transfusion unless

(*a*) the ABO and Rh groups of the patient's and donor's blood have been verified;

(*b*) a compatibility test between the patient's serum and the donor's red cells has been done.

Indiscriminate use of Group O blood is undesirable and may be dangerous because the serum of some Group O donors contains potent anti-A or anti-B antibodies which will destroy the red cells of an A, B or AB recipient.

1. Blood Samples

(i) *Adults and Children:* The ideal sample for blood grouping or compatibility testing is 5 to 10 ml. of blood collected with a dry, sterile syringe, and put into a dry, sterile tube. If a dry sterile syringe and needle are not available, a syringe and needle, sterilized by boiling, may be used. They should be rinsed with 0·9 per cent. sodium chloride solution or excess water should be shaken out. Syringes kept in spirit or other antiseptic should not be used since sterilization may be imperfect and haemolysis may be caused by traces of antiseptic solutions. The needle should be removed from the syringe before the blood is expelled into the test tube, since haemolysis may be caused by the ejection of blood under pressure through a fine bore needle.

(ii) *Infants:* In infants a stab wound should be made in the heel with a large needle, avoiding the bone, and at least 10 to 20 drops of blood should be collected in a dry sterile tube.

2. The Landsteiner (ABO) Blood Groups: The constitution of the ABO groups is:—

Blood Group	Approximate Frequency per cent. in Gt. Britain	Agglutinogen Content of Cells	Isoagglutinins present in Serum
AB	3·0	A and B	None, i.e., neither anti-A nor anti-B
A	42·0	A	Anti-B
B	8·5	B	Anti-A
O	46·5	O (i.e., neither A nor B)	Anti-A and anti-B

Since Group A occurs almost as frequently as Group O it is wasteful (as well as dangerous) to use Group O blood irrespective of the recipient's blood group.

3. Rh Blood Grouping: The Rh group of every person who is to receive a transfusion should be determined and, with certain exceptions, blood of the appropriate Rh group should always be given (see Section IX). These tests may take 2–3 hours and should be performed only by experienced workers. If in doubt of the procedure to be followed in a particular case the hospital pathologist should be consulted.

4. Compatibility Tests: Every blood transfusion should be preceded by a compatibility test, the details of which must be recorded. The request for this test should be sent to the laboratory as soon as possible after it has been decided to give a transfusion, in order to avoid haste and to afford time for the repetition of tests should the results prove doubtful. The onus of ensuring that this is done should rest with the clinician who is to give the transfusion. A fresh sample of the patient's serum for compatibility testing is normally required before each transfusion, if there has been an interval of more than two to three days since the last transfusion. However, compatibility tests for a series of transfusions, given within the course of a day or two, should all be performed with the original pre-transfusion sample of the recipient's serum. It is thus generally necessary to send a fresh sample of serum for compatibility testing with each request for blood, but a particular effort should be made to ensure that the first sample is large enough to be used for

a series of compatibility tests, should several transfusions be needed in the course of two to three days.

When application is made for a compatibility test, the full name of the patient, date of birth, ward, hospital number (and the name of the hospital if the blood is being prepared at the Regional Transfusion Centre or at another hospital) and the transfusion and obstetric history should always be given on the application form.

When delay may endanger life, a modified compatibility test can be done in 30–40 minutes, but the risk of errors is increased by doing tests hurriedly. If delay of this duration is too long, transfusion of plasma or a plasma substitute should be started and, in the interim, grouping and compatibility tests should be done. *It is emphasised that in very few instances is the urgency so great that a compatibility test cannot be done.*

For some exceptional reason it may be considered that it is undesirable to give plasma, or a plasma substitute, while a compatibility test is done, and that blood must be transfused without such a test. Those in charge of blood banks should decide in advance, if necessary in consultation with the Regional Transfusion Director, the procedure to be followed in such exceptional circumstances.

If a compatibility test is not performed, 2–3 ml. of blood should be withdrawn immediately before giving the transfusion and sent to the laboratory for blood grouping and compatibility testing with such bottles of blood as may have to be given subsequently.

All samples from patients used for blood grouping or testing compatibility should be kept in the refrigerator at 4°C.–6°C. or, if serum, frozen for not less than 2 days and preferably for at least 7 days after the transfusion since they may be needed for the investigation of reactions. [For a full consideration of blood grouping and compatibility testing see M.R.C. War Memorandum No. 9 and M.R.C. Memorandum No. 27.]

V. Administration of Transfusions

Practical instruction is essential. The following points are important:—

(1) Always examine the label on the bottle before giving a transfusion to ensure that blood of the correct group will in fact be transfused. Many incompatible transfusion disasters have occurred through neglect of this simple precaution. The patient's ful

name, hospital number and the name of the ward should be on the label of the bottle of blood to be used.

Blood is labelled in the following colours:—

Group AB ...	white	Group B ...	pale red
Group A ...	yellow	Group O ...	blue

Labels on the bottles of Rh-negative blood bear also a vertical red bar.

(2) Do not heat blood or plasma before use. It is safe to transfuse blood cold from the refrigerator except under special circumstances, e.g., exchange transfusions in infants. If warming blood is necessary, the bottle should be placed in water the temperature of which does not exceed 40° C. (104° F.). The temperature of the water should be measured with a thermometer. If blood must be warmed the doctor who is to give the transfusion, or the sister-in-charge, should supervise the process. Blood which has been haemolysed by overheating may cause death.

(3) Do not leave blood out of the refrigerator or insulated box for longer than 30 minutes.

(4) Do not reconstitute dried plasma until just before use.

(5) Most transfusions can be given by simple venepuncture. Select a vein in the forearm in preference to one in the antecubital fossa, especially with a restless patient, or during transport of a patient, since a needle in the antecubital fossa may be dislodged or driven through the vein, even when splinting is apparently secure, and precludes flexion of the elbow to the great discomfort of the patient.

(6) Do not cut down on a vein for it is hardly ever justifiable. If cannulation is unavoidable a vein in the leg, rather than one in the arm, should be used, except in patients undergoing abdominal operations or in obstetrical patients. The internal saphenous vein is the most convenient. It is found one or two inches proximal to the internal malleolus on the medial surface of the tibia. *Avoid, if possible, cutting down on a vein in the antecubital fossa.*

(7) Apply pressure with a tourniquet or a sphygmomanometer cuff (50–60 mm. Hg.) round the upper part of the limb to distend the veins.

(8) Employ palpation as well as inspection in selecting a vein. After sterilizing the skin inject a little local anaesthetic intradermally over the selected vein and leave it for ½–1 minute to take effect.

(9) Connect the transfusion apparatus with the bottle and ensure that it is in working order before the transfusion. First the clip should be tightly clamped on the distal length of rubber tubing

a few inches from the needle mount, and the rubber bung inserted in the bottle. When using the " piercing needle type " of set, the short piercing needle should be pushed through one segment of the rubber closure marked " 2 ". The long piercing needle, which serves as the air inlet, should then be thrust through the other segment marked " 2 ". During this manoeuvre the rubber tubing attached to this needle should be occluded and kept occluded while the bottle is being suspended and the tubing attached to the side of the bottle. The bottle should then be suspended at a height of 3–4 feet above the site of venepuncture. Let the rubber tubing, etc., hang full length; then hold the distal length of rubber tubing up in a U so that the distal end does not come above the level of the drip counter. This procedure is important if " flooding " of the drip counter is to be avoided. Slowly open the clip and allow the blood to expel all the air from the distal tubing.

To avoid spilling blood through the glass air-inlet tube of the bung type of set when the bottle is inverted to be suspended, a small sterile cork (provided in the set) is inserted in this tube. The cork must be removed after the bottle is suspended, otherwise the blood will not flow when the screw clip is released.

The cap which has been removed from the bottle should be placed, opening down, on the inner surface of the wrapping of the transfusion set, wrapped up and kept until the transfusion is finished. In some hospitals sterile caps are provided for recapping empty bottles after transfusions.

(10) Introduce the needle into the vein, release the tourniquet and fix the needle and rubber tubing securely in position with adhesive strapping in such a way that no pull is exerted on the needle.

(11) See that the patient is comfortable and that the arm or leg is suitably placed on a pillow if necessary and is kept warm during transfusion. Splinting may be advisable and is usually necessary if the patient is to be moved, or is restless or unco-operative.

(12) The patient should be watched closely during the first 30 minutes of a transfusion in order (*a*) to see that the desired rate of flow is in fact maintained and (*b*) to observe whether any untoward reaction occurs.

(13) When the transfusion is completed, replace the cap or caps and return the **UNWASHED** bottle or bottles, whether they have contained blood or plasma, to the laboratory without delay. In the event of some complication, e.g., haemoglobinuria or jaundice following transfusion, a sample of the fluid given will then be available for investigation. If no complication has occurred after 2 days, the bottle or bottles may be washed. **WASH THE SET IMMEDIATELY** by flushing with cold tap water from another transfusion bottle.

(14) If the transfusion stops inspect the set to see that the tubing is not kinked and examine the limb proximal to the needle to ensure that the vein is not being compressed, for example, by a rolled-up sleeve. Adjust the screw clamp. Inspect the position of the needle and manipulate it gently. If these simple manoeuvres do not re-establish the flow, close the screw clamp and disconnect the set from the needle. Test the patency of the needle by gentle suction with a sterile syringe partly filled with sterile saline solution; do not try to inject saline through the needle. Test the patency of the set by releasing the screw clamp. If either the needle or the set is blocked, a fresh needle or set should be substituted. Do not try to clear the obstruction by applying positive pressure in the transfusion bottle.

(15) Transfusions of blood or plasma or infusions of crystalloid solutions tend to be associated with thrombophlebitis if continued through the same giving set for more than 12 hours. (M.R.C. Report, Lancet, 1957-i-595). The incidence of this complication can be diminished by using a new giving set and changing the site of venepuncture every twelve hours.

VI. Transfusion Records

1. A record of every transfusion should be made in the patient's case notes AND, if issued, on the special card or form (N.B.T.S. 11) attached to the bottle. It is not always appreciated that the main reason for accurate recording is the protection of the patient.

Such records should show:—

(i) *Serial number of bottles of blood and plasma.* The recording of these numbers must never be omitted since they may be the only means of tracing and checking a donor's blood if there is any question of incompatible transfusion, or homologous serum jaundice. In the latter instance it is not only important to be able to trace the donor bearing the infective agent, but also to be able to trace and withdraw other bottles of the same icterogenic batches of plasma or serum. Only by the careful and invariable recording of serial numbers on bottles of transfusion fluid can this be accomplished. *All cases of homologous serum jaundice, suspect or proven, should be reported immediately to the Regional Transfusion Director.*

(ii) In transfusions for anaemia: the pulse rate recorded half-hourly, and the temperature recorded hourly, throughout transfusion and for four hours afterwards.

(iii) In transfusions for oligaemic shock: the pulse rate and blood pressure recorded at the commencement of transfusion and after each bottle of fluid transfused.

(iv) The time taken to give the transfusion.

(v) Results of urine analysis. The urine voided before every transfusion, and any urine voided during the transfusion and in the 24 hours afterwards should, whenever possible, be tested (colour, albumin test and examination of sediment). The reason for this is that the donor's blood may be abnormally rapidly destroyed and haemoglobinuria may occur, perhaps only once, and may be the sole evidence of this destruction. It is therefore important to examine all urine voided during and after transfusion.

(vi) Particulars of any immediate reactions to transfusion (for classification see below under " Complications and Dangers of Transfusion ").

2. Every hospital should keep records showing the following details of all transfusions of blood and plasma. This record should normally be kept by the medical officer in charge of the blood bank, i.e. usually the pathologist, or, in certain hospitals, by the hospital transfusion officer.

The blood bank register should show:—

(i) Date and time of removal of the blood from the blood bank.

(ii) Name of person fetching the blood from the blood bank.

(iii) Full name, ward, and hospital number of recipient.

(iv) Blood group (ABO and Rh) of recipient.

(v) Serial number and blood group (ABO and Rh) and date of collection of each bottle of blood transfused: (or the serial number of each bottle of plasma used).

(vi) Clinical condition necessitating transfusion.

(vii) Reactions, stating—

(*a*) their nature;

(*b*) whether patient has a history of miscarriage, still birth, hydropic, anaemic or jaundiced babies, or has had previous transfusions, or injections of blood or plasma.

(viii) Name of doctor giving the transfusion.

The plasma register should contain the same information with the omission of (iv).

3. The medical officer in charge of the above records should at regular and frequent intervals satisfy himself that blood and plasma issued to the wards or operating theatre has been used and that it is not being kept in ward refrigerators.

VII. Complications and Dangers of Transfusion

1. Febrile Reactions:

Classification. Grade 1. Rise of temperature to 100° F.;

Grade 2. Rise of temperature above 100° F. with sensation of chill but no actual shivering;

Grade 3. Rigor — with or without other symptoms.

The significance of a febrile reaction depends upon the cause. A febrile reaction during transfusion is an indication for stopping the transfusion. Fluctuations in temperature should be investigated to distinguish if possible those due to the patient's disease from those due to the transfusion.

2. Circulatory Overloading and Pulmonary Oedema: The danger of circulatory overloading exists mainly in patients with heart disease, chronic anaemia and cachectic states, severe sepsis, toxaemia, etc., in babies and in aged persons. The risk will arise if transfusion is too rapid or if the quantity of fluid transfused is too great for the particular case. Circulatory overloading can be prevented by giving transfusions slowly and by avoiding transfusion of excessive amounts of fluid. The ideal material for severe anaemic states is concentrated red cells.

3. Haemolysis in Transfusion: A haemolytic reaction due to incompatible transfusion is avoided by transfusing strictly homologous blood, i.e., blood of the same ABO and Rh (D antigen) groups as those of the recipient, which has been subjected to a compatibility test. Group O (including group O Rh negative) blood should not be used indiscriminately since the antibodies in the blood of certain Group O donors are sufficiently potent to destroy the red cells of a Group AB, A, or B recipient. Very occasionally a similar situation may arise when Group A or B blood is given to a Group AB recipient.

A haemolytic reaction, similar to that following the transfusion of incompatible blood may follow the transfusion of out-dated blood, or blood which has been haemolysed by freezing, overheating or infection.

The symptoms of a haemolytic reaction vary from case to case. Usually there is a rapidly developing febrile reaction, sometimes after as little as a few ml. of blood have been given, accompanied by dyspnoea, intense headache, a feeling of constriction of the chest, and pain, sometimes intense, in the lumbar region. The reaction usually occurs during or immediately after transfusion but signs and symptoms may not appear for some hours. None may be apparent in the unconscious or anaesthetised patient. Haemoglobinuria and jaundice may occur. Several hours will usually elapse before the onset of jaundice and it may be delayed for a few days. Haemoglobinuria is usually transient. Acute cardiac failure or suppression of urine is the usual cause of death.

Treatment of haemolysis following transfusion: When haemolysis following transfusion, due to incompatibility or any other cause, is suspected the transfusion should be stopped immediately and expert advice should be obtained. Treatment should be based on the principle of assisting the renal excretion of haemoglobin where this is possible, but it is important to appreciate that the patient's kidney function may have been so impaired by the haemolytic reaction that the secretion of adequate amounts of urine is temporarily not possible. With correct management, controlled fluid and sodium balance, etc., the patient can be tided over this phase of renal failure and restoration of kidney function may be expected, within 7–21 days in most cases. While awaiting expert advice therefore, the following treatment may be instituted. (The quantities are suitable for the average adult weighing 10 stones and should, if necessary, be adjusted.)

(i) If the patient shows signs of oligaemic shock, steps must be taken immediately to restore the general circulation by transfusion of compatible blood, plasma, or a plasma substitute. Delay increases the risk of renal damage.

(ii) If fluids can be taken by mouth, 1 litre of water should be given within a period of half to one hour.

(iii) If fluids cannot be taken by mouth, 1,000 ml. of 5 or 10 per cent. glucose in distilled water should be infused intravenously.

(iv) A fluid balance chart must be kept.

In the absence of a satisfactory urinary output following these measures no further attempts should be made to promote a water diuresis. The case must be recognised as one of renal failure and, for a considerable period, the intake of salt and water must be limited strictly to that necessary to cover renal and extra-renal

losses only. In addition, an adequate calorie intake should be secured to limit tissue protein breakdown and the consequent liberation of potassium.

These requirements can be accomplished by giving 600 ml. of 50 per cent. dextrose in water a day either by gastric drip or intravenously via a polythene catheter passed into the superior or inferior vena cava. The volume of any urine passed should be measured and an equivalent volume of fluid of the following composition added to the basic intake to cover the urinary loss of water and electrolytes:—

NaCl	:	3·2 g (55 m Eq)
NaLactate	:	2·2 g (20 m Eq)
Water to 1 litre		

Should the patient vomit, water and electrolyte loss via this route is made good by collecting the vomit, filtering through lint and returning it via the stomach tube. The oral administration of large quantities of fat, which often cause diarrhoea and vomiting, is not now recommended.

This regime should be continued until the phase of oliguria is succeeded by one of diuresis. This may be delayed for 7–21 days and experience has shown that the onset of the diuresis cannot be hastened by drastic procedures such as renal decapsulation or splanchnic block, which are unjustifiable and dangerous. The use of artificial kidney procedures, or peritoneal dialysis, are not required unless the above treatment was not begun for several days after the onset of anuria and the patient's serum potassium has risen to a dangerously high level. It is essential from the onset to maintain a good circulation and oxygen supply to the damaged kidneys and, if the patient is anaemic, the haemoglobin should be raised to at least 10·4 g. per cent. (70 per cent. Haldane) by the transfusion of concentrated red cells.

The regime outlined above should be continued for 2 days after a diuresis exceeding 1 litre per day has occurred. The patient has now passed into the early diuretic phase in which large quantities of water and electrolytes, especially potassium, may be lost. The urinary losses should be made good by the daily administration of a volume of fluid equal to that of the urine passed and having the following composition:—

NaCl	:	3·2 g (55 m Eq)
NaLactate	:	2·2 g (20 m Eq)
KCl	:	1·0 g (13 m Eq)
Water to 1 litre		

Additional water (500–750 ml) will be needed to balance insensible losses and at the same time a low protein high carbohydrate diet should be given.

This regime should be continued for as many days after the onset of diuresis as there were days of oliguria before it.

4. Embolism:

(i) Air Embolism: Positive pressure is sometimes applied to the transfusion fluid by attaching a bellows, e.g., a Higginson's syringe, to the air inlet tube. This manoeuvre is seldom necessary except when resuscitating patients or casualties with severe oligaemic shock. Rapid transfusion can also be achieved without positive pressure by using a 24/10 gauge needle in place of the usual 15/10 gauge giving needle.

If positive pressure is used the transfusion must be continuously supervised by a doctor who understands the dangers, and the pressure must NEVER be continued after the bottle is three-quarters empty. Positive pressure must never be used to overcome an obstruction in the giving set. If the lower part of the filter (in the bottle) has become blocked, and the level of blood has fallen sufficiently low, air may be forced into the giving set; or clots may be forced through the needle into the circulation.

Air embolism may also result from leaks or faults in the apparatus, or from faulty cannulation of a vein. The possibility of air entering the lumen of the tubing, after the tubing has been punctured to inject substances through the transfusion set, is diminished but not abolished if punctures are made as close to the giving needle as possible.

If air embolism is suspected the patient should be placed on his left side and kept in this position for two hours. Only gradually should his position then be changed and the patient closely observed for any symptoms.

(ii) Liquid plasma should not be used if it contains particles of fibrin since these may cause embolism.

5. Allergic Reactions: Skin rashes, urticarial weals and angio-neurotic oedema may complicate transfusion. Treatment is with adrenaline, anti-histamine products, etc., and de-sensitisation may be necessary.

6. Transfusion of Infected Blood: Never leave blood out of cold storage longer than 30 minutes. Interruption of refrigeration may allow chance contaminating bacteria to multiply and such blood may cause a severe or fatal reaction. The initial symptoms may be indistinguishable from those of a haemolytic reaction due to incompatible blood. The characteristic feature is the onset of extreme hypotension with warm extremities. Vomiting and diarrhoea may occur and there may be complaint of severe pain in the abdomen and extremities. The outcome appears to depend upon the degree of contamination of the transfused blood. Therapy

with antibiotics and infusion of such substances as nor-adrenaline to maintain the blood pressure form the basis of treatment.

7. TRANSMISSION OF INFECTION: Blood is collected by the Regional Transfusion Centres from donors in normal health and, as far as can be ascertained, free from diseases transmissible by transfusion. All such blood is subjected to a syphilis test. When fresh blood is taken from a donor and transfused immediately, i.e., fresh as opposed to stored blood, it is the *responsibility of the physician* to ensure that the donor is free from syphilis or other transmissible disease.

8. HOMOLOGOUS SERUM JAUNDICE: This complication is a risk attaching to the use of whole blood, plasma or serum. As far as is known the case incidence after the transfusion of dried small pool plasma or serum is little if any greater than that after whole blood (see Report, Lancet, 1954-i-1328).

All dried plasma or serum issued in the United Kingdom is prepared from pools made from not more than 10 blood donations.

Only a few instances of jaundice following the use of human thrombin have been recorded. None has been reported in this country following the use of human fibrinogen.

Homologous serum jaundice is clinically indistinguishable from infective hepatitis and occurs 40–150 days after transfusion. It is thought to be caused by a virus.

Serial numbers of bottles of blood or plasma used for transfusion should invariably be recorded in the case notes (see p. 14). If several bottles of plasma are to be given to one patient they should be of the same batch in order to reduce the risk of transmitting jaundice.

Cases of homologous serum jaundice, together with the serial numbers of the bottles of blood or plasma involved must, as already recommended, be reported immediately to the Regional Transfusion Director so that he can arrange to investigate the donors and to withdraw any plasma of the same batch which may remain unused.

VIII. Investigation of Transfusion Reactions

In the event of a severe reaction occurring the hospital blood bank should be notified. All severe reactions should also be notified by the hospital blood bank to the Regional Transfusion Director.

The following specimens are needed, initially, to make an investigation:—

(1) The blood samples used for the compatibility test before transfusion, or the pre-transfusion sample (see Section IV, Compatibility Tests). Such samples should be kept in the refrigerator for not less than 2 days after every transfusion.

(2) The remains of blood or plasma in the bottle or bottles, used for transfusion. (All bottles of blood or plasma used for transfusion should be kept in the refrigerator (4° C.–6° C.) for 48 hours after use lest investigations prove necessary. After the lapse of this time they should be washed.)

(3) A 10–20 ml. sample of blood from the patient collected into a dry, sterile tube with a dry, sterile syringe 3 hours after the reaction. Put about 2 ml. into an oxalated tube and the remainder into a dry, sterile tube.

(4) A clean sample of urine. All urine voided for 2 or 3 days should be measured and examined; abnormally coloured urine should be conserved for investigation.

Most haemolytic reactions are accompanied by haemoglobinaemia or hyperbilirubinaemia, or both, but these phenomena will depend upon the rate of destruction and elimination of the transfused blood, upon the rate at which the blood is given, and when the sample is taken. Examination of a sample of blood for these features is often the quickest way to decide whether a reaction is or is not haemolytic. If the observed rise of haemoglobin concentration does not approximate to the expected rise and no obvious cause, e.g., haemorrhage, can be found, the possibility of a haemolytic reaction, the so-called " silent " or " inapparent reaction ", should be considered.

IX. The Rh Factor

The Rh group of a recipient should always be determined, since about 50 per cent. of Rh-negative recipients, irrespective of their sex, may develop antibodies to the Rh factor if transfused with Rh-positive blood. A proportion of Rh-negative mothers may become immunized by the Rh factor during pregnancy by bearing Rh-positive foetuses, which have inherited the Rh factor from their fathers. Any of these immunized persons, if transfused subsequently with Rh-positive blood, may respond by destroying the donor's red cells; a fatal haemolytic reaction may occur. Moreover, a single transfusion of Rh positive blood may so sensitize an Rh-negative female to the Rh factor that any subsequent Rh-positive offspring may be affected with haemolytic disease of the newborn. Ideally, therefore, all patients should be transfused only with blood of homologous Rh group.

There are very few occasions on which there is not time to group the patient and do a direct matching test. In some grave emergencies there may not be time to do this and the tendency is then to use Group O Rh-negative blood although only 1 out of every 6 or 7 patients will, in fact, be Rh-negative. If the ABO group is known, however, use can then be made of Rh-negative blood of the same ABO group.

Rh-negative blood is essential for the transfusion of Rh-negative females before and during the child-bearing age, and for patients already sensitized to the Rh factor. Rh-negative blood of any ABO group is also relatively scarce and therefore its use for patients who are not Rh-negative accentuates its scarcity for those patients who should only receive such blood.

It may happen exceptionally that, in an emergency, when a recipient is known to be Rh-negative, no Rh-negative blood is available. In many of these instances plasma or a plasma substitute can be used satisfactorily while blood of the appropriate group is obtained and blood grouping and direct-matching tests are being done. The value of these fluids for this purpose appears to be insufficiently appreciated. Nevertheless, there may be occasions when blood must be given at once and only Rh-positive blood is available for an Rh-negative unsensitized patient. In such circumstances, the clinician must be told of the position by the pathologist and, if he agrees with the proposal to give Rh-positive blood, the risk must be taken. At other times, because of a local shortage of Rh-negative blood for the foreseeable needs of Rh-negative females before and during the child-bearing age, and of patients already sensitized to the Rh factor, it may be necessary to use Rh-positive blood for Rh-negative nulliparous females past the menopause who have not been transfused before and for Rh-negative males who have not been transfused before. Here again

the risk may have to be taken (after consultation between pathologist and clinician), but consideration should always be given to the use of plasma or a plasma substitute, as already mentioned, while it is confirmed with the Regional Transfusion Centre that there is no possibility of Rh-negative blood becoming available in time. Obviously all hospital staff should regard it as a duty in their use of transfusion therapy to avoid the wasteful use of Group O Rh-negative blood at any time and so to prevent this dilemma from occurring.

If for any reason Rh-positive blood has been given to a patient of unknown Rh group, the pre-transfusion sample should be submitted for Rh grouping without delay.

The Rh-negative patient who has received Rh-positive blood must thereafter be considered a " dangerous recipient ". Reliance for detecting such patients must rest essentially upon obtaining a proper history especially of previous transfusions and following the correct procedure whenever a transfusion is to be given i.e., using a request form and performing the blood grouping and direct matching tests by suitable techniques.

Further protection for such a patient against trouble from future transfusions may also be afforded by carrying out the following procedures:—

(*a*) Entry, by the clinician in charge of the patient, of full details of transfusions in the case history notes which should be distinctively marked.

(*b*) Examination of the patient's serum, if possible, and preferably at the Regional Transfusion Centre, for the presence of atypical antibodies, bearing in mind that the appearance of antibodies may be delayed for 3 to 4 months. A negative result is, of course, not to be taken as removing the patient from the group of dangerous recipients.

An infant suffering from haemolytic disease of the newborn, due to Rhesus immunization of an Rh-negative mother, should be transfused with Rh-negative blood of its own ABO group although the infant is Rh-positive.

NOTE: Sensitization of the mother to antigens of other blood group systems (e.g. ABO and Kell) may also occur during pregnancy and be associated with haemolytic disease of the newborn.

(For a full consideration of the Rhesus Factor see, " The Rh Blood Groups and their Clinical Effects ". M.R.C. Memorandum No. 27, London, H.M.S.O., 1954).

(85837) Wt. 52475—2502 28,500 1/58 D.L. (*T.S. 31416*)